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APPLICATION FOR UNITED STATES LETTERS PATENT

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TITLE:

STRETCHABLE COMPOSITE MATERIAL HAVING CONTINUOUS GATHERS

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Str tchable Composite Material Having Continuous Gath rs

Field of the Invention

This invention relates to stretchable or elastic composite materials that have a wide variety of uses and applications. More particularly, this invention relates to elastic cross direction composite materials that have continuous gathers and to methods of making such materials.

Background of the Invention

Elastic composite materials have a wide variety of uses and applications. For example, they are used in product areas such as disposable garments, apparel, diapers and training pants, adult incontinence products, feminine hygiene products, surgical gowns, surgical drapes, disposable swim wear, sweat bands, painting drapes, bandages, air filters, equipment covers and mattress covers. The present invention provides a new and useful stretchable composite that may have application in these as well as other areas. For example, this composite may also be suited for installation in disposable diapers, pants and adult incontinence articles as waistbands, stretch side panels, closure tapes, frontal tapes, back panels, leg bands, and the like. This composite may also be suited for installation in portions of other types of garments, such as in wrist bands of sweaters, waist bands of trousers, elastic portions of athletic sportswear, as well as many other articles of clothing.

Summary of the Invention

In an embodiment of this invention there is provided a stretchable composite material comprising: a first layer; a second layer; a plurality of elastic members; the elastic members located between the first and second layers and being in contact with the first and second layers; regions of securement securing the elastic members, first and second layers; and the composite having a maximum elongation of at least about 85% of the

elongation of an elastic member. This composite material may have elastic members slightly out of parallel, or the elastic members may be roughly parallel or parallel. This composite material may further have the plurality of elastic members comprised of a single strand and may also have the regions of securement approximately equally apart from each other. Further, this composite material may have a maximum elongation of at least about 90% of the elongation of an elastic member, or at least about 95% of the elongation of an elastic member. This composite material may also further comprise at least one stiffened edge.

In another embodiment of this invention there is provided a stretchable elastic composite comprising a first layer, a second layer, and a plurality of elastic strands; the composite further having a machine direction and a cross-machine direction; the length of the elastic strands being roughly transverse to the machine direction; zones of attached elastics interspersed between zones of unattached elastics; the zones of attached elastics being roughly parallel to the machine direction of the composite; the zones of attached elastics extending across at least more than two of the elastic strands; and the composite having pleats that are roughly parallel to the machine direction and extend across at least two of the elastic strands. This composite material may have at least one layer as a non-breathable material, a breathable material, a water impervious material, or a water pervious material or may have a first and second layer that is any combination of these materials. This composite material may have zones of attached elastic that have some, little or no elasticity, or it may have zones of attached elastic that extend across the majority of the elastic strands. This composite material may further have pleats extending across a majority of the elastic strands and may also have at least one stiffened edge.

In yet another embodiment of the invention, there is provided a stretchable elastic composite comprising a first layer, and elastic material; the composite further having a length and width; the elastic material further having a length and a width; the length of the elastic material being roughly transverse to the length of the composite; regions of securement

interspersed across the width of the elastic composite and roughly parallel to the length of the composite; the regions of securement extending across at least more than two of the elastic materials; the composite having pleats that are roughly parallel to the length and that extend across a majority of the elastic material; and the composite having a maximum elongation of at least about 85% of the elongation of the elastic material.

In yet a further embodiment of the invention, there is provided an article of apparel comprising a stretchable elastic composite of the above embodiments.

In still a further embodiment of this invention, there is provided a stretchable composite material comprising: a first layer, the first layer being a breathable material; a second layer, the second layer being a breathable material; at least two elastic members, the elastic members positioned in between the first and second layers; regions of securement securing the elastic members, the first layer and the second layer; the regions of securement further comprising attached zones; the attached zones extending across a majority of the elastic members.

Drawings

Figure 1 is a sketch of a stretchable composite material.

Figure 1A is a sketch of a cross-section a attachable composite material.

Figure 2 is a sketch of a stretchable composite material configured for use as a pant side panel.

Figure 3 is a sketch of a stretchable composite material in a cover.

Figures 4-19 are schematics of diagrams of an apparatus useful in making stretchable composite materials.

Figures 20 a-e are sketches of stretchable composite materials.

Figures 21-25 are sketches of stretchable composite materials.

Detailed D scription of Pr f rr d Embodiments of th Invention

A stretchable composite material is shown in Figure 1. The stretchable composite 1 has a first layer 2, a second layer 3 and an elastic material 4. The stretchable composite 1 is further characterized by having gathers or pleats 5 that run generally transverse to the longitudinal direction of the elastic material. In use, sections of the composite shown in Figure 1 may be cut out of the material and incorporated into articles of clothing. These cut-outs may be taken in any size, shape or position from the composite, as by way of example, as shown in Figure 2. Alternatively, the entire composite may be used, as by way of example, as shown in Figure 3.

Generally, the first and second layers may be the same or different materials depending upon the application to which the composite will be put. These layers may be films, non-wovens, wovens, synthetics, and blends of the forgoing. They may be breathable, non-breathable, have pores (and have pore sizes to permit or exclude a desired size material from passing through). They may be water permeable, water impermeable or have a specific water permeability. Further, they may be engineered to provide other qualities that are desirable for a particular end use.

The elastic material may be virtually any elastic type material that is available. It may be in the form of strips, ribbons, connected ribbons or strips, sheets, strands, threads, filaments, or any combination of these shapes and others known to the art. The elongation of the elastic material will depend on the end use to which the product is to be put, as well as the construction of the composite, such as the manner of holding the two layers together and the composition of the two layers. The elastic material may be a continuous strand as shown in Figure 1 or it may be a series of separate strands that run parallel, slightly out of parallel, so as not to intersect in between the two layers, or substantially out of parallel so as to intersect between the two layers. Further, the edges of the composite material may be trimmed so that the area in which the elastics intersect or the area where the single strand loops around would be removed. Alternatively, the edges or ends of the composite may be stiffened by adhesives, heat, ultrasonics, the

addition of extra material, or other techniques known to the art to increase the rigidity of the edge.

Figure 1A shows a cross-section of a stretchable composite. In that figure there is shown an elastic material 4, a first layer 2, a second layer 3, regions of securement 6 which are attached zones, and pleats 5. As shown in this figure, the pleats 5 would also constitute zones of unattached elastics.

The stretchable composite may be made by oscillating an elastic strand and capturing that strand between two facings or layers. The facings are adhered to each other and to the elastic strand by roughly parallel regions of securement, which are formed roughly perpendicular to the longitudinal dimension of the elastic strand by adhesives or other bonding means, such as, and without limitation, glues, heat, pressure, ultrasonics or other techniques and materials known to the art or combination thereof. Adhesive type materials may be applied by slot coating techniques, controlled spraying, gravure, screen printing, or other techniques known to the art that provide for a controlled application of such material. These regions of securement may be from about 1/32 of an inch (0.8 mm) or smaller in width to about 3½ inches (90 mm) or larger in width, and optimally range from about 1/8 inch (3.2 mm) in width to about 2 inches (51 mm) in width. The spacing between them may be the same as the width of the securement region or it may be different. Additionally, the securement regions may have varying widths.

Thus, by way of example, referring to Figures 21 and 22, the regions of securement 1 can be varied to produce any desirable range of elongation of the final composite as well as a controlled appearance of the continuous gathers. The composite shown in Figure 21, for example, would have three continuous gathers of similar appearance running the length of the composite, which would have an elongation in the width wise direction (top to the bottom of the drawing). The composite shown in Figure 22, would have seven continuous gathers running the length of the composite, and every other secured region would be different because of the alternating narrow 1b and wide 1a securement regions. In addition, the composite shown in

Figure 22 would have a lower elongation than that in Figure 21, because of the increased number and area of securement regions, assuming of course that elastic strand 26 was elongated the same amount in both cases when the composites for Figures 21 and 22 were made. Of course, any combination and number of narrow, intermediate, and wide securement regions can be employed to create desired composite elongations and desired appearance of the continuous pleats.

A typical adhesive used in the construction of the stretchable composite material is 2525A commercially available from Ato Findley Adhesives, Inc. located in Wauwatosa, Wisconsin. The adhesive is typically applied in a range from about 5 to about 60 g/m^2 , more typically in a range from about 8 to about 40 g/m^2, and most typically in a range from about 14 to about 22 g/m^2.

In general, the stretchable composite has gathers that are generally continuous and generally follow the orientation of the securement regions. The gathers also generally traverse more than two of the elastic strands and ideally a majority of the elastic strands and optimally will traverse all the elastic strands in a generally perpendicular fashion. These gathers, if spaced appropriately, can give the material a finished look, such as a pleated look, which can make the material look like a tailored product in a durable garment.

It has been found that these gathers greatly improve the comfort and fit of garments using the stretchable composite, as well as increasing the elastic range of the composite. That is the composite with these gathers shows a greater percentage elongation for the same elongation and size of elastic filament than a composite that does not have these elastic gathers.

For example, a panel made using 1/8 inch (3.2 mm) securement regions, spaced apart by 1/8 inch (3.2 mm) and having the elastic strands placed in under 250% elongation will have a maximum elongation length of about 240%. Thus, this composite would have a maximum elongation of about 96% of the elongation of the elastic material. Under the same conditions, it would be expected that a composite made by conventional

techniques would have a maximum elongation length of about 212%. This conventional material would have a maximum elongation of about 84.8% of the elongation of the elastic member. Thus, the elastic composites of the present invention allow for a much greater use of the elongation put into the strands and provide for a material that for the same initial elongation can have a substantially larger maximum elongation. For example, the composite material of the present invention has an elongation of at least about 85% of the elongation of the elastic material, ideally at least about 90% of the elongation of the elastic material, and optimally at least about 95% of the elongation of the elastic material.

Depending upon the type and elongation of the elastic material, the type of material used in the layers and the type and amount of material used to hold the layers together in the regions of securement, the elastic properties of the elastics in the those regions may be partially or completely masked. These areas of the composite are referred to as attached zones and would be characterized by reduced elasticity of the composite in that zone, regardless of the elasticity of the elastic in that zone. These attached zones of the composite may exhibit decreased elasticity, ranging from an elasticity that is less than the areas of unattached elastic to no elasticity at all.

This stretchable composite material lends itself to mass production. For example, quite commonly the materials used for the layers will be available in rolls. (Although, the stretchable composite material may be made by hand, or from individual sheet stock.) As these rolls are unwound, the material may be fed into an apparatus to assemble the composite. The machine direction of the apparatus and a composite made by an apparatus is the direction that the material moves through the apparatus. The cross-machine direction is the direction transverse to the direction of movement through the apparatus.

As the material moves through the apparatus, the adhesive may be applied in rows that are roughly parallel to the direction that the material is moving through the apparatus, i.e., the machine direction. The elastic material, which is under elongation, may than be oscillated back forth in the

cross-machine direction (i.e., a direction transverse to the machine direction) in between the two layers as they move through the apparatus and are joined together. Thus, the elastic material is captured between the two layers. The elastic would be under elongation during this oscillation step and would be kept under elongation while it is captured between the two layers.

There are many apparatuses known to the art that can manufacture the composite material. Examples of such apparatus are disclosed in PCT WO 96/23464, which is assigned to Moelnlycke, and has Gustafsson as a named inventor.

An apparatus that may be used to manufacture these composite materials is also disclosed in PCT WO 97/06299, which is assigned to E.I. du Pont De Nemours and Co, which disclosure is incorporated herein by reference. Apparatus of the type shown in this PCT publication may also be available under a license from du Pont and may be commercially obtained from AccraTec in Appleton, Wisconsin. Generally referencing Figures 4 to 19, the apparatus of the type disclosed in the du Pont PCT publication comprises three main components; namely, a cam-driven guide housing 30, pin conveyors 40, 40' and a sheet forwarding and supporting unit 50.

In this apparatus, housing 30 contains cylindrical cam 32 that drives strand traverse guide 36 to cause strand 10 to be looped around pins 42, 42' of a pair of pin conveyors 40, 40' to form a strand array 16. A layer or sheet 12 is advanced on sheet support unit 50 and assembled with strand array 16 and optionally with a cover sheet 14 to form composite sheet material 18, which then can be wound up or forwarded to further processing operations.

In accordance with the process disclosed in the DuPont PCT application, strand 10 is supplied to strand traverse guide 36 from below the guide as shown in Figures 4 and 8, or from above the guide as shown in Figure 7. When spandex, see description below, is employed as the strand to be incorporated into the composite sheet material, a simple feed path is preferred for the strand from the supply to the traverse guide with as few idler rolls as practicable. One idler roll may suffice to feed the strand from a supply package (e.g., a bobbin or a cake) to the traverse guide. Such a feed

path minimizes the amount of friction and elongation to which the strand is subjected and permits smoother, more uniform feeding of strand to the apparatus. Typically, the spandex is supplied to the apparatus with an extension of 10 to 400% beyond the relaxed length of the spandex.

As illustrated in Figures 9, 11, 14a, 14b, and 15, strand traverse guide 36 has cam follower portion 38 that is mounted in groove 33 of rotating cylindrical cam 32. Strand guide 36 rides between upper and lower rails 34 and 35. As cylindrical cam 32 is rotated, strand traverse guide 36 traverses a path that is perpendicular to and intersected by the paths of pins 42, 42' carried by two spaced-apart pin conveyors. In the figures, the pin conveyors are illustrated as pin conveyor wheels 40, 40'. Each wheel has a plurality of pins 42, or 42' projecting from its circumference. As wheels 40, 40' are rotated, strand 10 is looped by strand traverse guide 36 around each pin, first on a pin of one pin-conveyor wheel and then on a pin of the other pin-conveyor wheel, to form strand array 16. For each cycle of the traverse guide to and from, each pin-conveyor wheel is advanced by the angular distance between successive pins. Strand array 16 is then carried by the rotating pin-conveyor wheels into contact with advancing sheet 12 as the sheet is fed from supply roll 13 onto and advanced by a sheet support surface, illustrated in the figures as rotating drum 50. A short distance upstream of the location where strand array 16 contacts advancing sheet 12 an adhesive, preferably a hot melt adhesive, is applied to the strand array and/or the sheet by spraying, dripping, printing, slot coating, or other means. In Figures 4, 8 and 10, the adhesive is applied through adhesive spray applicator 20. The strand array is carried by continued rotation of the pin-conveyor sheets into one or more nips located near each edge of the strand array. The nips are formed by restraining belts 52, 52', preferably V-belts, and the circumferential surface of rotating drum 50.

To obtain spaced apart regions of securement, i.e., running roughly parallel to the machine direction, the adhesive is applied in discrete sections across the width (cross-machine direction) of the sheet. Thus, the adhesive would be applied in a striped pattern, with the stripes running roughly parallel

to the machine direction. This would encompass the adhesive being applied in non-straight lines, such as waves, or a sinusoidal pattern. This is to be contrasted with the conventional method of applying the adhesive across the entire width, cross-machine direction, of the sheet, as is shown in the du Pont PCT publication. Optimally, these discrete sections of adhesive are applied by using a slot coat technique. The other techniques described herein, as well as other bonding techniques known to the art, may also be employed to obtain discrete regions of securement across the cross-machine direction of the sheet.

Strand array 16 then is removed from the pins and held by the restraining belts atop advancing sheet 12 on the drum surface. Optionally, a cover sheet 14 fed from supply roll 15 may be applied atop the just-formed strand array/sheet assembly. By setting the traverse speed and the pin spacing on each pin conveyor, and then adjusting the relative speeds of the pin conveyors and the sheet-advancing support, the number of transverse strands per unit length of composite sheet material produced can be varied as desired. As the assembled sheet substrate 12, strand array 16 and optional cover sheet 14 are advanced, the adhesive becomes set and composite sheet material 18 is completed. Then, the composite sheet can be wound up or forwarded to further processing operations.

When the strand employed is an elastic strand (e.g., spandex), the resultant composite sheet material 18 can be cut in an optional subsequent step substantially parallel to the direction of the transverse strands to form elastic tapes or swatches. Then, the elastic tapes or swatches can be attached as elastic waistbands, side panels, closure tapes, frontal tapes, back panels and leg bands to disposable apparel, such as, diapers, pants and adult incontinence articles. High speed equipment of the kind disclosed by Merkatoris et al, U.S. Patent 5,296,080, is suitable for the attachment of the elastic components. Composite sheet material 18 formed with a strand that is not elastic is useful as strand-reinforced fabric, film, laminate, and the like. In such uses, strand 10 may be made of high tenacity fibers or filaments

of polymers such as nylon, aramid, polyolefin, or polyester, or of glass or the like.

As used herein the term "strand" includes any monofilament, multifilament or staple yarn, thread, ribbons or the like. The strand can be of any decitex suitable for the application for which the resulting composite sheet material is intended. The strand can be made of synthetic or natural fibers. For elastic composites, the strand can be of natural or synthetic materials such as rubber, spandex or other elastomeric material. The term "spandex" has its usual generic meaning; namely, fiber made from a long chain synthetic polymer that comprises at least 85% by weight segmented polyurethane. The spandex is employed with no lubricating finish on its surface so that better adhesion can be obtained between the spandex and the sheets.

Sheets suitable for use as advancing sheet substrate 12 include, without limitation, film, woven fabric, knit fabric or nonwoven fabric. The fabrics can be of natural or synthetic fibers such as cotton, wool, polyester, nylon, polypropylene, polyethylene, or the like. The films can be of polyethylene, polyester, polyfluorocarbons, polyamide, polypropylene, or the like.

Composite sheet materials 18 may have desirable resistances to impact, puncture and tear. Properties of the composite sheet can be further enhanced by processing the composite sheet material through the apparatus again one or more times. Uses for these composite sheet materials include tarpaulins, cargo curtains, bags, inflatable structures, hospital gowns, disposable coveralls, and the like. In some uses, elastomeric and reinforcing strands can be used advantageously together.

Cam/traverse-guide housing 30 encloses rotatable cylindrical cam 32. Housing 30 also supports upper and lower guide rails 34, 35, between which strand traverse guide 36 is mounted. Housing 30 also prevents lubricating oil used on the cam from spraying into the work area. A 30-weight oil is suitable for lubricating the cam. Figure 11 is a front view of housing 30, with a portion cut away to show cylindrical cam 32 within. Cylindrical cam 32 has groove

33 cut into its surface. The cylindrical cam is rotated by means not shown through cam shaft 31. As shown by Figures 14a, 14b and 15, strand traverse guide 36 comprises a tip 37 for holding the strand and a base 38 which acts as a cam-follower. The base or cam-follower portion 38 of strand traverse guide 36 is seated in cam groove 33 and slides through the groove path as cylindrical cam 32 is rotated. Rotation of grooved cylindrical cam 32 causes strand traverse guide 36 to slide to and from between the straight edges of upper and lower guide rails 34 and 35. Figure 12 is a front view detail of the cylindrical cam 32 with groove 33 in which the strand traverse guide cam follower 38 is to be seated. An access notch, not shown, can be provided in one of the guide rails for convenient installation of the strand guide in the cam groove and between the guide rails. A lead-in channel, not shown, connected to the groove in the circumferential surface of the cam, in a position that can be aligned with the access notch in the guide rail permits convenient seating and removal of the strand guide.

Figures 13a, 13b, and 13c show three developed surfaces or "profiles" of cams for use in the apparatus. Each profile represents the complete surface of a cylindrical cam laid out in a plane. The curve represents the complete surface of a cylindrical cam laid out in a plane. The curve represents groove 33 of cylindrical cam 32. In operation, the cam follower of the strand traverse guide follows the groove path. The profile represents one rotation of the cam and results in one to and from traverse of the strand traverse guide. Alternatively, suitable cams can have more than one rotation of the cam resulting in one to-and-fro traverse of the strand traverse guide. In following the groove of the cam profile shown in Figure 10a, the strand guide reverses direction immediately upon reaching the extreme end of its traverse. This cam is very similar to the cam disclosed in Akers et al, U.S. Patent 3,675,863. The flattened portions of the profile of Figure 13b generate some "dwell time" at the extreme ends of the traverse by flattening of the profile. The dwell time increases the clearance of the strand guide around the pins of the pin-conveyor wheels and allows higher process speeds to be attained. Accordingly, the profile of Figure 13b may be

preferred over the profile of Figure 13a, which provides no dwell time at the point of traverse reversal. A further improvement in cam profile is shown in Figure 13c, in which a small angle, α, of less than 1 degree, is created between the flattened dwell portion of the profile and the edge of the cam. This maintains a small side pressure on the yarn guide so that it smoothly enters the turn at the end of the dwell section, thereby reducing wear on the guide and permitting higher speeds.

Figures 14a, 14b, and 15 show in greater detail cam follower 38 and tip 37 of strand traverse guide 36. The cam follower is seated to slide within groove 33 of cylindrical cam 32 causing guide 36 to slide to and from between guide rails 34 and 35. In operation, as shown in Figures 4-9, as cylindrical cam 32 is rotated, strand traverse guide 36 moves strand 10 to and from to loop the strand about pins 42, 42' of pin-carrying conveyors 40, 40'. Pins 42, 42' are driven in a semicircular path that sweeps through the path of the strand traverse guide (after the guide has passed) to engage the strand 10. Figures 9 and 14a depict guide rails 34, 35 as flat. Figure 14b depicts an upper guide rail 34, preferred for bottom-fed strand, having a shallow depression or groove in its surface at the region of closest approach of the pins 42, 42' to rail 34. This permits the pins to sweep more deeply through the strand traverse path without hitting the guide rail. Also, as shown in Figures 14a and 14b, for bottom fed strand, upper rail 34 is recessed by an angle θ, usually of less than 10 degrees, to further assure a close, unimpeded approach of the pins to the strand traverse path. The close approach of the pins to the face of the guide rails assures that as the pins contact the strand, the strand is secured in the notch of the traverse guide tip. Details of the notched tip of the strand guide are depicted in Figures 15 and 16. Such notched guide tips are disclosed by Altice et al, U.S. Patent 3,086,722. If the strand is fed from above the apparatus, the central axis of the semicircular path of the pins preferably is positioned slightly below the path of strand traverse guide, and the hollows or grooved areas are on the lower guide rail to accommodate the path of the pins.

In an embodiment of a system, tip 37 of the guide 36 extended about 0.098 inch (2.5 mm) above the base of the strand guide and had a notch about 0.060-inch (1.5 mm) deep. Of course, guides of other dimensions can be used satisfactorily. Figure 16 illustrates a key-hole shaped notch for the tip of the strand traverse guide. The key-hole notched tip is preferred for better retention of the strand in the guide. To minimize wear and friction, tip 37 is constructed of a ceramic material having a surface roughness no greater than 32 micro inches RMS. When a plastic guide is employed, the ceramic tip can be integrally molded with the plastic to form the completed guide. For smoothest operation, the weight of the traverse guide weight is minimized. A typical plastic traverse guide with ceramic tip can weigh as little as 5 to 10 grams.

As shown in Figures 4-8, strand 10, carried by reciprocating strand traverse guide 36, is looped around pins 42, 42' of a pair of pin-carrying conveyors 40, 40' to form a strand array. As illustrated in Figures 4-8, the pin-carrying conveyors are wheels, each having a plurality of pins projecting from its surface. A pin-carrying conveyor wheel is located near each end of the guide traverse path. The pin-conveyor wheels are spaced apart a distance that is somewhat less than the full stroke of the traverse guide. As referred to herein, the stroke of the traverse guide is equal to one-half the length of the full to-and-fro traverse of the strand traverse guide. As referred to herein, the stroke of the traverse guide is equal to one-half the length of the full to-and-fro traverse of the strand traverse guide. Figures 17a and 17b respectively depict a typical pin-conveyor wheel 40 with a plurality of pins 42 projecting outwardly from the wheel. The wheel has a central annular cylindrical hub 41 for mounting a drive shaft (not shown). The pins can be press-fit, brazed, welded, or bonded into spaced holes in the wheels. Typically, they are rotated at a rate in the range of 100 to 600 revolutions per minute; at least 200 rpm is preferred.

In another embodiment of the pin wheels, to ease strand removal from the pins, the pins can be made retractable, as for example by a cam and spring mechanism. As illustrated in Figures 4 and 8 for bottom-fed strand,

the axes of the pin-conveyor wheels are positioned slightly above (for example, by about 2.5 mm) the elevation of the strand traverse guide path to allow deeper penetration of the pins across the path of the strand guide. As illustrated in Figure 7 for top fed strand, the axes of the pin-conveyor wheels are positioned slightly below the elevation of the strand traverse guide. Pin-conveyor wheels 40, 40' are driven by conventional means not shown in synchronization with the traverse guide. The pin-conveyor wheels are spaced from each other by a distance that is shorter than the traverse guide stroke but sufficiently long to permit restraining belts 52, 52' to capture the ends of the strands. The angular location of pins on the circumference of one wheel is off-set from the angular position of the pins on the circumference of the other wheel by one-half of the pin spacing. For high speed looping of strand around the pin of the pin-conveyors, a minimum clearance 0.040 (1 mm) between the strand traverse guide and the pins of the pin-conveyor wheels has been found to be satisfactory.

The detail drawings of Figures 18a and 18b, show a pin 42 canted at an angle β from the plane of wheel 40 and projecting from the surface of the pin-conveyor wheel. A typical pin can project 0.25 inch (6.4 mm) from the surface. The pin is directed slightly away from the center of the strand traverse path to improve the ability of the pin to hold the strand securely in place on the wheel. Angle β can be as large as 45 degrees, but usually is smaller. As illustrated in Figure 18b, the pin has a shoulder about 2/3 of the distance from the point at which the pin is secured to the wheel to the exposed end of the pin. A shoulder located between 0.4 and 0.8 of said distance usually ensures satisfactory looping of the strand.

In Figures 19a and 19b respectively, the pin-conveyor wheels 40, 40' are schematically shown to be canted toward or away from each other. Such arrangements are particularly useful with elastomeric strand. As shown in Figure 19a, strand 10 is formed into a looped strand array on the pin-conveyor wheels, and the canted wheels allow the strand to retract before the strand is laid down on the sheet substrate carried by sheet support drum 50. In Figure 19b, strand 10 is formed into a looped array on the pins of the

pin-conveyor wheels and then elongated by the canted wheels before being laid down on the moving sheet. With this latter configuration, a shorter traverse stroke and therefore, higher speeds can be used. While on the pins, a spandex strand typically can have an elongation that is in the range of 10 to 400% beyond its relaxed length.

As illustrated in Figures 4-8, sheet 12, which is to become the substrate of the composite sheet material 18 to be produced, is advanced on the surface of sheet support drum 50. Drum 50 is positioned so that at least a part of its circumferential surface is between pin-conveyor wheels 40, 40'. Other sheet support surfaces contemplated for use in supporting the sheet in its passage between the pin-conveyor wheels, include for example, an endless flat belt or screen. An endless belt is advantageous when additional time is required for maintaining the strand array and sheet assembly restrained while the adhesive is set. To keep laid-down strand array 16 in position atop advancing sheet substrate 12, a pair of restraining belts 52, 52' are employed. Restraining belt 52 is driven by contact with the moving sheet support drum around a set of four idler rolls 54, 55, 56 and 57; belt 52' is driven in the same way around corresponding idler rolls 54', 55', 56' and 57'. Idler rolls 54, 54' are positioned so that strand array 16 is initially captured at the nip between the belts going around rolls 54, 54' and rotating sheet support drum 50 before the strand looped around pins 42, 42' of pin-conveyor wheels 40, 40' is removed from the pins. Drum 50 can have circumferential grooves aligned with the restraining belts to aid the belts in holding the advancing strand array and sheet in position on the drum. Idler rolls 54, 54' are of small diameter so that the distance between the point at which the strand is contacted by the restraining belts and the point at which the strand is fully captured in the nip between the belts and the drum is as small as practicable. Located immediately upstream of the nips between the restraining belts and the drum, is adhesive applicator 20, which applies adhesive to the strand and/or advancing sheet. A wide variety of adhesives are suited for use in the apparatus, such as hot melt spray adhesives. The total width of sheet that may be affected by the adhesive applied to the

strand and/or sheet is designated "W" in Figure 2 and may be a little shorter than the distance between the restraining belts. In addition, adhesives, ultrasonics or other bonding type means may be used to stiffen the edges of the composite.

Restraining belts 52, 52' are preferably V-belts and more preferably grooved V-belts. Such belts hold the strand and sheet on the sheet support drum more securely than do belts of round or flat cross-section. The belts are made of flexible materials to permit proper passage of the belt around the smallest diameter idler rolls (i.e., 54, 54'). Restraining belts 52, 52' operate at the same linear speed as the circumferential speed of sheet support drum 50. Immediately downstream of the just-described belt/drum nips, cutters 60, 60' are positioned on each side of drum 50 (as best illustrated in Figures 5 and 10). Various types of cutters can be used, such sharp edges, hot wire cutters (i.e., electrically heated resistance elements), or any other means suitable for the particular kind of strand being cut. Instead of employing cutters, stripping fingers may be positioned so as to lift the loops of strand off the pins after the strand is engaged by the restraining belts. Using stripping fingers leaves loops at the selvage of the final composite sheet product. Optionally, a press roll 58 can be used to press a cover sheet 14, supplied from roll 15, atop restrained assembly of strand array 16 and sheet substrate 12, while the assembly is still on the support drum and before the applied adhesive has set. A takeoff roll 65 can be used to guide the completed composite sheet material away from the drum and to a suitable collection means or to further processing steps. The assembly of strand, sheets and adhesive are restrained on the drum for a sufficient time (or distance on the drum) to permit the adhesive applied to the strand and sheet to set.

Figures 20a-e show various patterns of the regions of securement and patterns for the elastic strands on the layers or sheets that can be made. These patterns are provided by way of example and not limited to those disclosed. Figure 20a shows a composite employing a plurality of elastic members made from a single strand of elastic 10, and having the same width and evenly spaced apart regions of securement 27, which are also positioned

on the edge of the composite. Figure 20b shows a composite employing a strand of elastic 10, and having the same width and evenly spaced apart regions of securement 27, which are positioned away from the edge of the composite. Figure 20c shows a composite employing two strands of elastic 10, and having the same width regions of securement 27 that are unevenly spaced apart across the width of the composite. Figure 20d shows wider regions of securement 27, two elastic strands 10, and that the regions of securement are evenly spaced. Figure 20e shows an alternative pattern for the elastic strands 10 and unevenly spaced apart regions of securement 27 having varying widths. Any combination of multiple or single elastics strands, evenly or unevenly spaced apart regions of securement, the same or different widths of the regions of securement, or pattern of the elastics strands may be employed.

Moreover, changing these parameters can provide pleats that may be arranged in patterns or vary in spacing and size. This may be accomplished, for example, by having the distance, or region of unattachment 28, between the securement region 27 different in the same laminate or by having the width of the securement region different in the same laminate as shown in Figure 23. Additionally some of the securement regions 27 may be discontinuous as shown in Figure 24.

EXAMPLE 1

This example describes a test that demonstrates the suitability of the process and apparatus disclosed in the du Pont PCT application for making elastic composite material at high speed. The apparatus for making this elastic composite material is substantially as illustrated in Figure 4. The process also can be carried out using other embodiments shown herein or on other types of apparatus.

The starting materials are as follows. A 620-dtex LYCRA® XA™ spandex (sold by E. I. du Pont de Nemours & Co., Wilmington, DE) is used as the elastic strand. A 23.3-g/m^2 Type 6700 thermally bonded polypropylene nonwoven fabric (sold by Fiberweb Group Inc., Simpsonville, NC) is used as substrate sheet or layer. A 0.001 inch (0.025 mm) thick

polyethylene film (sold by Consolidated Thermoplastics Co., Dallas, TX) is used as cover sheet or second layer.

Findley 2276 hot melt adhesive (sold by Ato Findley Adhesives, Inc., Wauwatosa, WI) is slot coated onto the substrate sheet in ½ inch (12.7 mm) stripes evenly spaced apart by ½ inch (12.7 mm) at about 15 gsm.

The strand is fed under elongation to reciprocating strand guide which is driven by a cylindrical cam rotating at 2,000 rpm (rotations per minute). The strand is supplied at an extension of about 300% beyond its relaxed length. The strand traverse guide has a 9.5 inch (23.5 cm) stroke and makes 2,000 to-and-fro cycles per minute. A pair of parallel pin-conveyor wheels, 8.75 inches (22.2 cm) apart (i.e., the minimum distance between the imaginary circles formed by the centers of the bases of the pins on each wheel) and each of 6.37 inch (16.2 cm) diameter are rotated at 200 rpm. Each pin-conveyor wheel has ten pins equally spaced apart by a circumferential distance of 2.0 inches (5 cm). The pins are canted outward by 20 degrees from the wheel circumferential surface. The cam profile is as given in Figure 13b. The positions of the pin wheels and strand traverse guide are set to provide a clearance of at least 0.04 inch (1 mm) between the pins and the strand traverse guide near the end of each traverse stroke. The axes of the pin-conveyor wheels are located 0.15 inches (3.8 mm) above the elevation of the axis of the path of the traverse guide. Figure 18b illustrates the configuration that is used for the pins and the pin-conveyor wheels. Each pin is of circular cross-section and has a shoulder of the design illustrated in Figure 18b. The pins project above the wheel surface. The pin shoulder is located 0.07 inch (1.8 mm) from the exposed tip of the pin. The large diameter portion of the pin is 0.060 inch (1.5 mm) and the small diameter portion (i.e., the portion closest to the exposed tip of the pin) is 0.038 inch (1 mm). The sheet support drum has a 9.5 inch (23.5 cm) diameter and is rotated at 25 rpm. The resultant composite sheet material is removed from the drum at a linear velocity of about 19 meters per minute.

EXAMPLE 2

An example of one of the many uses for the composite material of this invention is in the side panels of disposable absorbent garments. An optimal material for such elastic side panels is a material that is breathable and consists of two layers of spunbond polypropylene that have an elastic strand glued between them as shown in Figure 2. As shown in that figure, the elastic side panel 7 has elastic strands 26 that are glued between two layers of spunbonded polypropylene. The elastic strands extend in the width wise dimension 19 of the panel. They are not parallel, but instead move closer together towards the end of the panel in what could be characterized as a zig zag pattern. As shown in Figure 2, ideally the elastic strand is a single filament that was placed in the zig zag pattern. Alternatively, however, multiple strands of elastic may be used including parallel strands. The elastic strand 26 is held in place between the layers of spunbond by the use of adhesives or ultrasonics. The adhesive may be any of the types disclosed herein or known to the art. Optimally, and depending upon the amount of attachment of masking of the elastic properties in the attachment zone that is desired, the adhesive may have elastic properties when set, such adhesives would be commercially available from, by way of example and without limitation, National Starch & Chemical Company, Bridgewater, NJ, and Ato Findley Adhesives, Wauwatosa, WI. The adhesive is applied by a slot coat technique in a spaced apart roughly parallel glue lines 27 that are positioned lengthwise (transverse to the width-wise dimension 19) of the panel. The glue lines have a width of 1/8 inch (3/2 mm) and the space between each glue line is 1/8 inch (3.2 mm). The glue is applied at about 15.2 gsm. The panel has pleats and gathers that run the entire length of the panel and cross all the elastics. In this example, the edge of the composite material may be stiffened by the use of ultrasonic bonding in a dot pattern that runs the entire length of the side of the panel and extends into the panel by about 3/4 of an inch.

<u>EXAMPLE 3</u>

An example of a potential application for a composite material is shown in Figure 3, which shows a large cover or drape having composite

elastic material around its edges. The composite elastic material has elastic material 2, pleats (not shown in the Figure), and regions of attachment 3.

EXAMPLE 4

An example of a stretchable composite is provided in which the glue lines 27 and regions of securement 27 are roughly parallel to the cross-machine direction of the composite, as shown in Figure 25. In this example, the elastic strands 10 are roughly parallel to the machine direction of the composite. These regions of securement may be made by using glue lines that are applied by a screen printing technique. Thus, the composite of this example would be extendable, i.e., capable of elongation, in the machine direction, whereas the composite of Example 1, would be capable of elongation in the cross-machine direction.